

# A NEW FAMILY WITH A FOURTH LEPTON FLAVOUR

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We present here arguments in favor of the existence of the most lightest lepton and its neutrino. This new family with a fourth lepton flavour in the first turn must uncover so far unobserved universal properties of matter. The unity of their laws predicts the flavour symmetrical schemes for the decays of the electron and the proton. Thereby, it admits the new modes in the decays of the muon, tau lepton and the neutron. At the same time, in all these transitions no conservation laws are violated.

## 1. Introduction

The unity of the symmetry laws establishes in nature a highly important connection between the different spin states of each of all types of massive fermions. Such a principle regardless of what is the mechanism of the flavour symmetrical mode of the neutrino oscillation [1], may be interpreted as a regularity criterion of unification of fermions at the new level that to any type of the left (right)-handed lepton corresponds a kind of polarized neutrino [2]. This unites all particles of the same leptonic families in a unified whole [3]. Then it is possible, for example, to define the family structure of leptons in the presence not only of the left-handed but also of the right-handed doublets [4]. They may be written as

$$..., \begin{pmatrix} \nu_e \\ e^- \end{pmatrix}_L, (\nu_e, e^-)_R, \begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix}_L, (\nu_\mu, \mu^-)_R, \begin{pmatrix} \nu_\tau \\ \tau^- \end{pmatrix}_L, (\nu_\tau, \tau^-)_R, ..., \quad (1)$$

$$..., \begin{pmatrix} \bar{\nu}_e \\ e^+ \end{pmatrix}_R, (\bar{\nu}_e, e^+)_L, \begin{pmatrix} \bar{\nu}_\mu \\ \mu^+ \end{pmatrix}_R, (\bar{\nu}_\mu, \mu^+)_L, \begin{pmatrix} \bar{\nu}_\tau \\ \tau^+ \end{pmatrix}_R, (\bar{\nu}_\tau, \tau^+)_L, .... \quad (2)$$

Such a presentation is based logically on the question as to what is the value of masses of so far unknown families of leptons [5, 6].

Each family of the known leptons of different components has his a self flavour [7, 8]. Therefore, at a given stage, it should be characterized any particle by the three ( $l = e, \mu, \tau$ ) lepton flavours:

$$L_l = \begin{cases} +1 & \text{for } l_L^-, l_R^-, \nu_{lL}, \nu_{lR}, \\ -1 & \text{for } l_R^+, l_L^+, \bar{\nu}_{lR}, \bar{\nu}_{lL}, \\ 0 & \text{for remaining particles.} \end{cases} \quad (3)$$

Conservation both of full lepton number

$$L_e + L_\mu + L_\tau = const \quad (4)$$

and of all the lepton flavours

$$L_l = const \quad (5)$$

is, by itself, not excluded [9]. This indicates to that the decays

$$\mu^- \rightarrow e^- \bar{\nu}_e \nu_\mu, \quad \mu^+ \rightarrow e^+ \nu_e \bar{\nu}_\mu, \quad (6)$$

$$\tau^- \rightarrow e^- \bar{\nu}_e \nu_\tau, \quad \tau^+ \rightarrow e^+ \nu_e \bar{\nu}_\tau, \quad (7)$$

$$\tau^- \rightarrow \mu^- \bar{\nu}_\mu \nu_\tau, \quad \tau^+ \rightarrow \mu^+ \nu_\mu \bar{\nu}_\tau \quad (8)$$

and other reactions with leptons become possible owing to an origination in them of the difermions

$$(e_L^-, \bar{\nu}_{eR}), \quad (e_R^-, \bar{\nu}_{eL}), \quad (9)$$

$$(e_R^+, \nu_{eL}), \quad (e_L^+, \nu_{eR}), \quad (10)$$

$$(\mu_L^-, \bar{\nu}_{\mu R}), \quad (\mu_R^-, \bar{\nu}_{\mu L}), \quad (11)$$

$$(\mu_R^+, \nu_{\mu L}), \quad (\mu_L^+, \nu_{\mu R}) \quad (12)$$

of a definite flavour [3, 4].

Each paraparticle here is responsible also for conservation of summed electric charge. Thereby, they express the idea of charge quantization law.

According to one of its aspects [10, 11], the value of lepton electric charge  $e_l^E$  is connected with some universal charge  $e_0^E$  and equal to

$$e_l^E = n e_0^E, \quad (13)$$

in which  $n = 0, 1, 2, \dots$ , and  $e_0^E$  is predicted as an electron charge.

It is interesting, however, that the electron, muon and tau lepton having an equal charge, possess the different masses. On the other hand, as was noted in the work [12] for the first time, a mass spectrum of elementary particles must be restricted from above and below by the masses of the limiting size.

If we now take into account that the difference in masses of leptons follows from the unified principle [13], then there arises a question of whether the acceptance of fundamental charge  $e_0^E$  in (13) as an electron charge is not strictly nonverisimilar even at the availability of its universality properties.

Here it is relevant to recall the mass-charge duality [14], according to which, any of all types of charges may serve as a certain indication to the existence of a kind of inertial mass. Herewith the mass and charge of an electroweakly charged lepton are naturally united in rest mass  $m_l$  and charge  $e_l$  equal to the electroweak ( $EW$ ) mass and charge

$$m_l = m_l^{EW} = m_l^E + m_l^W, \quad (14)$$

$$e_l = e_l^{EW} = e_l^E + e_l^W, \quad (15)$$

consisting of the weak ( $W$ ) and Coulomb ( $E$ ) parts.

Therefore without contradicting ideas of charge quantization law, we conclude that regardless of what are the maximally and minimally possible values of the electric and unelectric types of masses, the crossing of their spectra corresponds in nature to the existence of until presently unobserved particle with a certain universal mass.

Our purpose in a given work is to elucidate whether there exists any new family of leptons, and if so what is to be learned from these expected fermions about so far unknown properties of matter.

## 2. From earlier known to the new leptons

The above reasoning says about that nature itself relates each part of the unified mass of a particle to corresponding contribution of the structural components of its united charge. In the limit of electroweakly charged leptons, these connections [15] have the form

$$e_l^E = -g_{V_l} \frac{m_l^E m_l^W}{2m_W^2} \frac{1}{\sin \theta_W}, \quad (16)$$

where and further  $e_{l-}^E$  and  $e_{l+}^E$  distinguish from one another by a sign,  $m_W$  denotes the mass of  $W^\pm$ -boson, and constant

$$g_{V_l} = -\frac{1}{2} + 2 \sin^2 \theta_W$$

characterizes the vector part of leptonic ( $l = l, \nu_l$ ) weak current.

Universality of the size of  $|e_l^E|$  describes the fact that a multiplier  $m_l^E m_l^W$  presenting in (16) must be one of fundamental physical parameters. We are led, thus, to a lepton universality principle [15] that

$$m_l^E m_l^W = \text{const.} \quad (17)$$

The absence of one of masses  $m_l^E$  or  $m_l^W$ , as mentioned in (17), would imply that neither exists at all. From such a point of view, earlier experiments [16] about electric masses of leptons

$$m_e^E = 0.51 \text{ MeV}, \quad (18)$$

$$m_\mu^E = 105.658 \text{ MeV}, \quad (19)$$

$$m_\tau^E = 1776.99 \text{ MeV} \quad (20)$$

may serve as the first source of laboratory facts predicting the values of their weak masses

$$m_e^W = 5.15 \cdot 10^{-2} \text{ eV}, \quad (21)$$

$$m_\mu^W = 2.49 \cdot 10^{-4} \text{ eV}, \quad (22)$$

$$m_\tau^W = 1.48 \cdot 10^{-5} \text{ eV}. \quad (23)$$

The basis for our choice is that currents used in the devices for measurements of  $m_l$  and  $e_l$  have the purely Coulomb nature.

Masses of both types satisfy in addition a constancy of the size

$$m_l^E m_l^W = 26318.11 \text{ eV}^2, \quad (24)$$

which follows from a certain latent regularity of the nature of electroweak mass spectra of leptons.

There exist, however, the maximally  $m_{lmax}^K$  and minimally  $m_{lmin}^K$  possible limits both on the electric ( $K = E$ ) and on the weak ( $K = W$ ) masses of leptons in mass spectra of elementary particles.

Furthermore, if it turns out that  $m_l^E \rightarrow m_{lmax}^E$  implies  $m_l^W \rightarrow m_{lmin}^W$ , and  $m_l^W \rightarrow m_{lmax}^W$  says  $m_l^E \rightarrow m_{lmin}^E$ , comparing (18)-(20) with the corresponding masses from (21)-(23), it is easy to see a coincidence of their spectra

$$m_l^E = m_l^W, \quad (25)$$

which takes place only at

$$m_l^E \ll m_e^E, \quad m_l^W \gg m_e^W. \quad (26)$$

This property corresponds in nature to the same new type of charged lepton ( $l = \epsilon$ ) possessing the universal mass. It can be called the evrmion. We will use in addition the symbols  $\epsilon^-$  and  $\epsilon^+$  which denote the evrmion and its antiparticle.

One of the fundamentally important features of the suggested particle is the universality of the square of any of the structural parts of its mass. Indeed, uniting (17) with (25), we establish a connection

$$(m_\epsilon^K)^2 = m_\epsilon^E m_\epsilon^W = m_l^E m_l^W = \text{const}. \quad (27)$$

Thus, each of earlier experiments [17] about lepton universality [18-21] may testify in favor of the existence of the most lightest lepton, namely of

the evrmion having the electric mass and charge

$$m_\epsilon^E = 162,228 \text{ eV}, \quad (28)$$

$$e_\epsilon^E = 1.602 \cdot 10^{-19} \text{ C}. \quad (29)$$

Therefore, it is not surprising that if (27) does not change, the mass and charge of the evrmion play a role of units of mass and charge

$$m_0^E = m_\epsilon^E, \quad e_0^E = e_\epsilon^E. \quad (30)$$

Of course, our definition of fundamental constants (30) is not a standard one. This, however, requires the elucidation of the ideas of any of the existing types of masses and charges from the point of view of mass-charge duality.

### 3. Earlier known about the new lightest neutrinos

We see that nature itself cannot define the same components of mass and charge regardless of their other parts. It relates therefore each component of mass even in the case of a neutrino to corresponding part of its charge.

Furthermore, if neutrinos are of families of the studied types of leptons, this connection [22] appears as follows:

$$e_{\nu_l}^E = -g_{V_{\nu_l}} \frac{m_{\nu_l}^E m_{\nu_l}^W}{2m_W^2} \frac{1}{\sin \theta_W}. \quad (31)$$

Here  $e_{\nu_l}^E$  for the neutrino (antineutrino) has the negative (positive) sign.

Comparison of (31) with (16) transforms it to the form

$$e_{\nu_l}^E = \frac{m_{\nu_l}^E m_{\nu_l}^W}{m_e^E m_e^W} e_e^E. \quad (32)$$

Such a connection would seem to exist only in the case when the gauge symmetry [23, 24] is absent. But unlike the earlier descriptions of the nature of this invariance, its mass structure [25] establishes (32) from the point of view of the unified principle.

We recognize that (32) is incompatible with the charge quantization, if this law does not possess any structural properties. On the other hand, as stated in (32), each electrically charged particle says in favor of a kind of magnetically charged monoparticle [26]. In such a situation, the same

neutrino can lead to quantization of magnetic charges of all mononeutrinos and vice versa.

In a similar way one can as an example introduce an arbitrary electric charge [27]. At the same time, the standard electroweak theory [28-30], by itself, does not exclude a given procedure.

It is clear, however, that the available laboratory facts [16] define the upper limits of the neutrino mass and charge. There are the earlier [31] and the comparatively new [32] experiments, the analysis of which predicts the existence of neutrino universality. A beautiful example [32] is the following:

$$e_{\nu_l}^E < 2 \cdot 10^{-13} e_e^E. \quad (33)$$

The solutions (17) and (32) indicate herewith to a principle that

$$m_{\nu_l}^E m_{\nu_l}^W = \text{const}. \quad (34)$$

To the same implication one can lead by the way of the consideration of full lepton number, the conservation of which [22] establishes a connection

$$m_{\nu_e}^E m_{\nu_e}^W : m_{\nu_\mu}^E m_{\nu_\mu}^W : m_{\nu_\tau}^E m_{\nu_\tau}^W = m_e^E m_e^W : m_\mu^E m_\mu^W : m_\tau^E m_\tau^W. \quad (35)$$

Unification of (17) with (35) leads us to (34) once more, confirming the legality of the availability of an equality sign in it.

One of masses  $m_{\nu_l}^E$  or  $m_{\nu_l}^W$ , as noted in (34), can exist only in the presence of the second of them. From such a point of view, known experimental restrictions [16] on the electric masses

$$m_{\nu_e}^E < 2.5 \text{ eV}, \quad (36)$$

$$m_{\nu_\mu}^E < 0.17 \text{ MeV}, \quad (37)$$

$$m_{\nu_\tau}^E < 18.2 \text{ MeV} \quad (38)$$

suggest the measured for the first time sizes of the neutrino weak masses

$$m_{\nu_e}^W < 2.1 \cdot 10^{-9} \text{ eV}, \quad (39)$$

$$m_{\nu_\mu}^W < 3.096 \cdot 10^{-14} \text{ eV}, \quad (40)$$

$$m_{\nu_\tau}^W < 2.89 \cdot 10^{-16} \text{ eV}. \quad (41)$$

Their comparison gives the right to state that a constancy of multiplier

$$m_{\nu_l}^E m_{\nu_l}^W = 52636.22 \cdot 10^{-13} \text{ eV}^2 \quad (42)$$

is intimately connected with the character of its structure depending on nature of electroweak mass spectra of neutrinos.

They show that the existence both of the maximally  $m_{\nu_l max}^K$  and of the minimally  $m_{\nu_l min}^K$  limiting values of the electric and weak masses of neutrinos in mass spectra of leptons is practically not excluded.

Uniting (36)-(38) with (39)-(41) and by following that  $m_{\nu_l}^E \rightarrow m_{\nu_l max}^E$  expresses  $m_{\nu_l}^W \rightarrow m_{\nu_l min}^W$ , and  $m_{\nu_l}^W \rightarrow m_{\nu_l max}^W$  describes  $m_{\nu_l}^E \rightarrow m_{\nu_l min}^E$ , we observe the crossing of spectra of both types of neutrino masses

$$m_{\nu_l}^E = m_{\nu_l}^W, \quad (43)$$

which is realized only if

$$m_{\nu_l}^E \ll m_{\nu_e}^E, \quad m_{\nu_l}^W \gg m_{\nu_e}^W. \quad (44)$$

This picture has important consequences for the same new type of neutrino corresponding in nature to the evrmion. Therefore, from its point of view, it should be expected that the square of any of the structural components of the suggested particle mass possesses the universality properties. Indeed, starting from (34) and (43), we are led to a correspondence principle that

$$(m_{\nu_e}^K)^2 = m_{\nu_e}^E m_{\nu_e}^W = m_{\nu_l}^E m_{\nu_l}^W = \text{const}. \quad (45)$$

The latter together with (42) convinces us here that the fact [31, 32] of neutrino universality is the first confirmation of the existence of the most lightest neutrino, namely of the evrmionic neutrino having the electric charge (33) and mass

$$m_{\nu_e}^E < 7.255 \cdot 10^{-5} \text{ eV}. \quad (46)$$

It is not excluded, however, that if (45) holds, the mass and charge of the evrmionic neutrino refer doubtless only to the fundamental physical parameters. They of course characterize those particles, the charge of which is extremely lower then the charge of the evrmion.

#### 4. The fourth lepton flavour



These reasonings just and give the possibility to understand the unified principle, according to which, each of all types of leptons has his a self neutrino. If such a pair is the evrmion and its neutrino, they constitute the new leptonic families.

For elucidation of their ideas, it is desirable to present the family structure of leptons (1) and (2) in the general form by the following manner:

$$\begin{pmatrix} \nu_\epsilon \\ \epsilon^- \end{pmatrix}_L, (\nu_\epsilon, \epsilon^-)_R, \begin{pmatrix} \nu_e \\ e^- \end{pmatrix}_L, (\nu_e, e^-)_R, \\ \begin{pmatrix} \nu_\mu \\ \mu^- \end{pmatrix}_L, (\nu_\mu, \mu^-)_R, \begin{pmatrix} \nu_\tau \\ \tau^- \end{pmatrix}_L, (\nu_\tau, \tau^-)_R, \dots, \quad (47)$$

$$\begin{pmatrix} \bar{\nu}_\epsilon \\ \epsilon^+ \end{pmatrix}_R, (\bar{\nu}_\epsilon, \epsilon^+)_L, \begin{pmatrix} \bar{\nu}_e \\ e^+ \end{pmatrix}_R, (\bar{\nu}_e, e^+)_L, \\ \begin{pmatrix} \bar{\nu}_\mu \\ \mu^+ \end{pmatrix}_R, (\bar{\nu}_\mu, \mu^+)_L, \begin{pmatrix} \bar{\nu}_\tau \\ \tau^+ \end{pmatrix}_R, (\bar{\nu}_\tau, \tau^+)_L, \dots \quad (48)$$

Any evrmionic family here must distinguish itself from already known leptons by the individual flavour. This new lepton flavour ( $L_\epsilon$ ) can be called the evrmion number.

We have, thus, the real possibility to characterize each particle by the four ( $l = \epsilon, e, \mu, \tau$ .) lepton (3) flavours.

Conservation of full lepton number

$$L_\epsilon + L_e + L_\mu + L_\tau = const \quad (49)$$

and all the lepton flavours (5) indicates to the existence of the most diverse phenomena with evrmions and their neutrinos.

## 5. Mass criterion for the electron decay

If the lightest fermions having a fourth lepton flavour there exist, they must birth in the decays of the more heavy particles. An example of this may be a new scheme of the muon decay

$$\mu^- \rightarrow \epsilon^- \bar{\nu}_\epsilon \nu_\mu, \quad \mu^+ \rightarrow \epsilon^+ \nu_\epsilon \bar{\nu}_\mu. \quad (50)$$

Their legality follows from the unified force that unites the two left (right)-handed particles of the suggested evrmionic family in dievrmions

$$(\epsilon_L^-, \bar{\nu}_{\epsilon R}), \quad (\epsilon_R^-, \bar{\nu}_{\epsilon L}), \quad (51)$$

$$(\epsilon_R^+, \nu_{eL}), \quad (\epsilon_L^+, \nu_{eR}). \quad (52)$$

These parafermions say in favor of conservation of full lepton number and all four types of lepton flavours admitting the existence of the new scheme in the decay of  $\tau$ -lepton

$$\tau^- \rightarrow \epsilon^- \bar{\nu}_e \nu_\tau, \quad \tau^+ \rightarrow \epsilon^+ \nu_e \bar{\nu}_\tau. \quad (53)$$

We have already seen that any of the decays (50) and (53) is carried out in nature by the same criterion. Such a criterion can, for example, be a difference in masses of leptons. It establishes not only the lepton or neutrino universality but also a flavour symmetrical connection, at which originates the birth of dievrmions (51) and (52) in the transitions of one heavy lepton into another state with the lowest mass. In a given case, a new example of the possible  $\beta$ -transition is the electron decay

$$e^- \rightarrow \epsilon^- \bar{\nu}_e \nu_e, \quad e^+ \rightarrow \epsilon^+ \nu_e \bar{\nu}_e. \quad (54)$$

Many authors state that the electron must not decay. Its decay [33, 34] would seem to contradict our observation that stable electrons constitute the structural parts of ordinary matter.

At the same time, electron itself testifies in favor of the evrmion and its neutrino. Therefore, to understand the legality of the discussed procedure one must elucidate the nature of the corresponding mechanism responsible for the steadiness of matter itself.

This circumstance is more interesting if we turn to the masses of leptons, because they satisfy the inequalities

$$m_\epsilon^E < m_e^E < m_\mu^E < m_\tau^E, \quad (55)$$

$$m_{\nu_\epsilon}^E < m_{\nu_e}^E < m_{\nu_\mu}^E < m_{\nu_\tau}^E, \quad (56)$$

$$m_\epsilon^W > m_e^W > m_\mu^W > m_\tau^W, \quad (57)$$

$$m_{\nu_\epsilon}^W > m_{\nu_e}^W > m_{\nu_\mu}^W > m_{\nu_\tau}^W, \quad (58)$$

which say about that each of transitions (50), (53) and (54) similarly to any of (6)-(8) cannot go at the expense of the weak currents, and is a result of Coulomb interactions. On the other hand, these conditions do not contradict that to each of the decays

$$\epsilon^- \rightarrow e^- \bar{\nu}_e \nu_e, \quad \epsilon^+ \rightarrow e^+ \nu_e \bar{\nu}_e, \quad (59)$$

$$\epsilon^- \rightarrow \mu^- \bar{\nu}_\mu \nu_\epsilon, \quad \epsilon^+ \rightarrow \mu^+ \nu_\mu \bar{\nu}_\epsilon, \quad (60)$$

$$\epsilon^- \rightarrow \tau^- \bar{\nu}_\tau \nu_\epsilon, \quad \epsilon^+ \rightarrow \tau^+ \nu_\tau \bar{\nu}_\epsilon, \quad (61)$$

$$e^- \rightarrow \mu^- \bar{\nu}_\mu \nu_e, \quad e^+ \rightarrow \mu^+ \nu_\mu \bar{\nu}_e, \quad (62)$$

$$e^- \rightarrow \tau^- \bar{\nu}_\tau \nu_e, \quad e^+ \rightarrow \tau^+ \nu_\tau \bar{\nu}_e, \quad (63)$$

$$\mu^- \rightarrow \tau^- \bar{\nu}_\tau \nu_\mu, \quad \mu^+ \rightarrow \tau^+ \nu_\tau \bar{\nu}_\mu \quad (64)$$

respond to the weak interactions. Of course, such transitions may be observed as the extremely fast processes if we herewith take into account that parafermions (9)-(12) and

$$(\tau_L^-, \bar{\nu}_{\tau R}), \quad (\tau_R^-, \bar{\nu}_{\tau L}), \quad (65)$$

$$(\tau_R^+, \nu_{\tau L}), \quad (\tau_L^+, \nu_{\tau R}) \quad (66)$$

appear in them as a consequence of the weak currents.

## 6. Leptons about the proton decay

For completeness we now turn to the charges of leptons, because from the law of their conservation in the processes

$$n^- \rightarrow p^- e^+ \nu_e, \quad n^+ \rightarrow p^+ e^- \bar{\nu}_e \quad (67)$$

it follows that the neutron and electronic neutrino possess the strictly identical electric charges [35].

In the same way one can reanalyze in the framework of the baryon [36] and lepton number conservation the new scheme of the neutron decay

$$n^- \rightarrow p^- \epsilon^+ \nu_\epsilon, \quad n^+ \rightarrow p^+ \epsilon^- \bar{\nu}_\epsilon. \quad (68)$$

It appears that here the transitions (68) say about the equality of the electric charges of the neutron and evrmionic neutrino.

Thus, (67) and (68) would seem to indicate that either both the neutron and the neutrino are the electrically neutral or the hypothesis about the identity of the electric charges of the proton, evrmion and the electron is not valid. On the other hand, as follows from the flavour symmetry, a formation of the parafermions (9), (10), (51) and (52) can be explained by the availability of a nonzero charge in neutrino [22]. At the same time, existence itself of the neutron decay is by no means excluded experimentally [16]. At

our sight, such a measurement can explain the unity of neutrino universality principle in the systems of all fermions with the charge of the evrmionic neutrino. This in turn implies that the fact [37] of lepton universality is the general and does not depend on the type of a particle with the charge of the evrmion. It is important only that its spin was equal to the spin of the evrmion.

If we start from the legality of a given procedure, using (27) and (45) for the nucleons, we would establish the following equalities

$$(m_{\epsilon}^K)^2 = m_l^E m_l^W = m_p^E m_p^W, \quad (69)$$

$$(m_{\nu_{\epsilon}}^K)^2 = m_{\nu_l}^E m_{\nu_l}^W = m_n^E m_n^W. \quad (70)$$

They together with (24), (42) and the available data [16] in the literature

$$m_p^E = 938.272 \text{ MeV}, \quad (71)$$

$$m_n^E = 939.565 \text{ MeV} \quad (72)$$

lead to the implication of laboratory estimates of the nucleon weak masses

$$m_p^W = 2.8049 \cdot 10^{-5} \text{ eV}, \quad (73)$$

$$m_n^W = 5.6021 \cdot 10^{-18} \text{ eV}. \quad (74)$$

Comparing their with the lepton masses, it is not difficult to see that

$$m_{\epsilon}^E < m_e^E < m_{\mu}^E < m_p^E < m_{\tau}^E, \quad (75)$$

$$m_{\nu_{\epsilon}}^E < m_{\nu_e}^E < m_{\nu_{\mu}}^E < m_{\nu_{\tau}}^E < m_n^E, \quad (76)$$

$$m_{\epsilon}^W > m_e^W > m_{\mu}^W > m_p^W > m_{\tau}^W, \quad (77)$$

$$m_{\nu_{\epsilon}}^W > m_{\nu_e}^W > m_{\nu_{\mu}}^W > m_{\nu_{\tau}}^W > m_n^W. \quad (78)$$

In these circumstances, any of the transitions (67) and (68) can carry out through the Coulomb interactions.

But here the difference in masses of fermions admits the weak processes of the proton decay by the schemes

$$p^- \rightarrow n^- \tau^- \bar{\nu}_{\tau}, \quad p^+ \rightarrow n^+ \tau^+ \nu_{\tau}. \quad (79)$$

The nucleons of both types possess in addition the strong interactions which are absent in leptons from the point of view of the standard electroweak

theory [28-30]. However, as was mentioned earlier [38], the neutrinos have with the field of emission the same strong interactions as the hadrons. Their existence in all types of leptons could refine the crossing point of spectra of masses of a different nature.

## 7. Conclusion

So, it is seen that the evrmion has the lowest electric mass within the four families of leptons and cannot decay by means of the Coulomb interactions. Instead it possesses the large weak mass and almost always decays through the weak interactions.

The electron and the muon are of those fermions, in which the decay is carried out by the two most diverse ways either at the expense of the Coulomb or at the expense of the weak interaction.

Among the set of the studied fermions only the  $\tau$ -lepton and neutron have the extremely lower weak mass and must not decay by means of the weak currents. However, their decay through the Coulomb interactions is not forbidden, since at such processes appears a crucial part of the electric mass. The weak mass of the proton is responsible for its transition into the neutron,  $\tau$ -lepton and neutrino with the lowest weak mass.

But in all these decays no masses are separately conserved [39] even at the account of their sign for the fermion and the antifermion. At the same time, neither of the investigated transitions is forbidden by any other conservation laws. Therefore, it is important to elucidate what are the selection rules which express the idea of mass conservation law.

To establish their, we will start from the fact that

$$\sum_l e_l^E = const, \quad \sum_{\nu_l} e_{\nu_l}^E = const \quad (80)$$

corresponds in any process of  $\beta$ -decay to the charge conservation.

Jointly with (16) and (32), these selection rules are reduced to

$$\sum_l m_l^E m_l^W = const, \quad \sum_{\nu_l} m_{\nu_l}^E m_{\nu_l}^W = const. \quad (81)$$

At first sight unlike the charge, no mass possesses the additivity properties. On the other hand, as we have already said, each of the charges satisfying the additivity conditions must be universal physical parameter. At the same

time, fermion itself can possess simultaneously both the mass and the charge of the fermion or its neutrino.

Taking into account this and that

$$\sum_l e_\epsilon^K = const, \quad \sum_{\nu_l} e_{\nu_\epsilon}^K = const, \quad (82)$$

we cannot exclude the existence for the square of any of elementary particle universal masses of the additive selection rule

$$\sum_l (m_\epsilon^K)^2 = const, \quad \sum_{\nu_l} (m_{\nu_\epsilon}^K)^2 = const. \quad (83)$$

Thus, nature itself unites the laws of conservation of mass and charge in a unified whole. Thereby, it characterizes the behavior of electroweakly charged fermions both from the point of view of the Coulomb and from the point of view of the weak parts of their mass. Therefore, each of all types of masses of any particle may serve as a criterion for a kind of scheme of its decay unless this is forbidden by unification laws.

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